***Marking*:** Colored collars, ear tags, or dyes have been used for years to identify individual pronghorn, but radio collars now are used most often to follow seasonal movements of pronghorn, identify causes of mortality, and delineate home ranges.

Figure 22. Pronghorn are often marked as an aid for later location or identification. Such techniques are of special value during mortality and seasonal movement studies, or locating herds translocated. Pictured here is an adult buck with a small marker in the left ear. It is purposely small, thereby assisting in marking the animal for life history activities, but still not easily seen by many public viewers. Photo by Jim D. Yoakum.

If visual recognition of individuals is desirable in addition to a radio collar frequency, fairly wide, ca. 3-in. (76 mm) colored collars are recommended. Narrow collars may be covered by mane and neck hair, making identification difficult. Wide collars can be observed from the air and individual markings easily discerned. R. Deblinger (pers. comm.) flew 50-100 feet (15-30 m) over pronghorn using a Piper Super Cub, and by slowing the plane down to pronghorn speed, could read the symbols or numbers on collars with little problem. Obviously, this technique can stress pronghorn, so care should be taken concerning the time of year and length of pursuit.

Collars should be tight enough that the animals cannot get a front foot or shrubbery caught in them. However, collars on sub-adults must allow for growth, and those on adult bucks must allow for neck swelling during the rut. Measurements of pronghorn from Colorado, Idaho, Montana, Nevada, Oregon, and Wyoming (Bear et al. 1973, McNay 1980, and Autenrieth 1984) indicate the following neck circumferences using as a maximum, the neck size immediately ahead of the shoulder, and the minimum as being just behind the ears. Adult bucks averaged 23.2 inches (590 mm) and 15.2 inches (386 mm), respectively. Adult females averaged 19.3 inches (491 mm) and 13 inches (330 mm). One-day-old fawns had neck measurements of 6.1-6.8 inches (155-172 mm).

Yearlings were so similar to adults that adult measurements can also apply for this age class.

Radio transmitters weighing no more than 0.26 lbs (120 g), including the collar, are less than 5% of the weight of a very small fawn. Generally, fawns are only one or two days old when collars are attached, requiring small, light batteries with a short life. The best radio collars for fawns have the transmitter and lithium battery hermetically sealed in a nickel-steel canister measuring about 1.5 by 1.4 by 1 inches (38 by 35 by 25 mm). The largest battery that should be put on a newborn fawn only has a life of 7-10 months and an expected range of 1.5-3 miles (2.4-4.8 km). Transmitters usually are riveted between strips of 1-inch (25 mm) nylon webbing that serves as the collar when the ends are joined. Most researchers do not want radio collars to remain on fawns for more than 3 months so that small, light batteries can be used. Several designs allow the radio collar to fall off before the batteries expire so that the collars can be retrieved. A simple design for short-term monitoring has the ends of the nylon webbing cut short and sewn to 1-inch (25 mm) wide elastic strips with strong nylon thread. These strips are sewn together with about 5 strands of light cotton thread to form an expandable neck collar. The cotton thread weakens with exposure and, as the fawn grows, and the tension on the collar increases, the threads break in 2-3 months. Tucks can be taken in the elastic with 2 or 3 strands of thread so the collar fits snugly. Successive tucks break away as the animal grows until the ends break and the collar falls off. Surgical tubing that is flexible and decomposes in 3-6 months has also been successfully used for fawn collars in Arizona.

When neck sizes increase greatly, nonadjustable collars may cause death. Keister et al. (1988) developed a durable, light-weight, self-adjusting radio collar for pronghorn fawns that allowed tracking animals up to one or more years of age. These collars were easy to attach and did not injure animals. Of 120 pronghorn fawns fitted with these collars, no deaths could be attributed to the collars, although five fawns were abandoned. The only problem was that some fawns lost their collars during the first few days—a problem remedied by adding a foam liner. Although collars lost resiliency with use, all retained enough tension to remain attached to necks of various sizes without becoming too tight. In about a year, however, some collars became slightly brittle and cracked. This weathering, along with the animals crossing through a number of barbed wire fences, contributed to some collar loss. But, because collar life was about equal to transmitter life, the potential for injury from collars was eliminated at about the same time as their usefulness was terminated.

Metal transmitters for fawns should be wrapped with dull-colored tape or painted, and the entire collar rubbed with sagebrush or other aromatic vegetation to mask unnatural odors. Carrying collars in a bag with vegetation from the study area also assists in this effort.

Solar-powered ear tag transmitters weigh about 0.06 lbs (25 g) compared to battery-powered adult collars, which weigh about 1 lb (454 g). Ear tag radios eliminate the risk of trying to fit a neck collar on a growing animal or a mature male whose neck

circumference increases during the rut. The ear tag should be placed about mid-ear to prevent the long hairs of the lower ear area from covering the solar panels. T. Pojar (pers. comm.) used 25 solar ear tag radios on 5-month-old pronghorn fawns with variable results. Three of the female fawns' solar tags tore out of the ear within 6 months indicating that the cartilage of female fawns may not be strong enough to retain the ear tag. This problem was not encountered in male animals of the same age. Signal strength of these 25 radios was highly variable, possibly due to manufacture design or position of the tag in the ear. Some radios performed as well as battery-powered radios while others were weak or sporadic.

Properly designed ear tag radios may provide long term tracking ability. A solar-powered ear tag on a male continued to emit a signal after five years in the field, even though, the antenna had broken off limiting the range of the signal (T. Pojar, pers. comm.).

Even with their shortcomings, solar-powered ear tags are worth considering for specific investigations. Ear tags are less cumbersome than collars, and although they may tear out, they may be the better choice for marking fawns depending on the duration of the study period. Further design improvements will facilitate marking male pronghorn because these transmitters do need to consider changes in neck circumference.

Figure 23. Radio collars weighing no more than a ¼ of a pound (120 g) and having small, short life batteries, are used for marking one or two day old fawns. Fawn collars made of surgical tubing are flexible, allow for neck growth, and decompose in three to 6 months. Photo by Richard Ockenfels.

Pronghorn are flighty, nervous animals and marking them with streamers or other materials that move in the wind is not recommended. Many pronghorn have been marked with metal ear tags, and such tags have been retained for 10 years in some cases. However, O'Gara (pers. comm.) handled a pronghorn in Montana that was sloughing metal ear tags, apparently after her ears had frozen around the tags, the temperature having fallen to below -30EF (-34EC) about two weeks earlier. Plastic tags for earmarking livestock are available in stores supplying farm and ranch equipment. Such tags have less chance of freezing ear tissue and are easier to see at a distance than metal tags. Although plastic ear tags became brittle after one or two years when first available, those used in recent years have held up well.

Pronghorn do not always have to be marked for individual identification. An animal's horn shape, color, width of neck bands, the amount of white pelage, the configuration of the black areas on the face, etc, all serve to make an individual pronghorn recognizable by an observer who is familiar with the animals he or she is

studying. From 1988 through 1994 Byers (1997) was able to identify all of the adult pronghorn on the National Bison Range (n = 84 to 136) by using sketches and photographs to help memorize their physical characteristics and coat patterns.

Translocations: Transplanting pronghorn should be considered only after it has been determined that the new or additional animals can survive in a habitat possessing sufficient quantity and quality of forage, water, and space in historic rangelands without being in conflict with other environmental issues (McCarthy and Yoakum 1984). Every translocation should be preceded by a feasibility study or management plan to document the objectives, translocation procedures, and post-release monitoring of the animals in their new habitat.

At times, sportsmen's organizations, conservation groups, agency personnel or local governments recommend translocating pronghorn into unsuitable areas. Such endeavors resulted in the loss of all pronghorn transported to Florida (Elliott 1966) and Hawaii (Nichols 1960). Analysis of these two cases disclosed the proposed sites did not meet pronghorn habitat requirements. Ignoring basic biological needs results in the eventual death
of translocated animals, misuses of public funds, and elicits a negative reaction from the public as to the credibility of wildlife managers (Yoakum 1978). Similar unsuccessful translocations have been made into areas of unsuitable habitat in other U. S. states and in Mexico.

One of the first procedures for determining potential suitability of an area for the translocation of pronghorn to grassland habitats was developed by the Colorado Division of Wildlife (Hoover et al. 1959). Twenty-eight years later, the International Union for Conservation of Nature and Natural Resources (1987) proposed almost the same criteria, and summarized them as consisting of a feasibility study, a preparation phase, a release or introduction phase, and a follow-up phase. In many cases, the feasibility studies and preparation phases have been inadequate and the follow-up phase has neglected.

The trapping and translocating of pronghorn involve large amounts of manpower, time, and finances; therefore, it is recommended that feasibility studies and management plans be developed prior to authorizing any release. These plans should provide detailed procedures for capture, transportation, and release into new habitats. Management plans should specify the numbers of animals to be captured, and identify specific release sites. To ensure that the animals are captured and handled as safely as possible, the presence of a veterinarian at the capture site is highly recommended. The plan also should provide particulars regarding methods of release and follow-up monitoring.

Translocation goals should address the question of establishing a viable herd. Relocated herds that increase 20-30% within 5-10 years after release are indicative of herds that are responding to suitable habitat conditions. Franklin (1980) considered 50 breeding adults the minimum for a viable population. It therefore seems reasonable that translocations should contain at least 50 to 100 animals as recommended by Hoover et al. (1959). The only exception might be an emergency situation if some animals already

were present in a release area judged to be below carrying capacity. Franklin also suggested 500 randomly mating individuals as the minimum population size for sustaining genetic variation at a level that would enable the species to adapt to changes in the environment. This appears appropriate for pronghorn, especially on rangelands experiencing frequent severe winters and/or numerous droughts.

Determining Suitable Release Sites - the initial factor to be evaluated for a release site is whether the area was historically occupied by pronghorn. Sites not historically inhabited apparently lacked some necessary habitat component. Any proposed release site should be evaluated as to why the site is not currently supporting the desired number of animals. To this effect, the following questions must be answered: what caused the animals to become extirpated and has the factor or factors responsible for their elimination been corrected? Has the habitat or other conditions now improved sufficiently to meet the pronghorn's habitat requirements? And, are current land uses and landowner attitudes favorable towards a re-introduction.

Translocations have assisted pronghorn populations in increasing from 30,500 in 1924 to more than 1,000,000 in 1984 (Yoakum 1986). Many of the translocations during the last 50 years were successful (Fisher 1942, Thompson 1947, Stokes 1952, Hoover et al. 1959, Russell 1964, Menzel and Suetsugu 1966, Yoakum 1978, and Britt 1980). Others, however, were unsuccessful (Aguirre and Sotomayor 1981, Tsukamoto 1983, McCarthy and Yoakum 1984, Del Monte and Kathman 1984). Improved techniques and knowledge from past experiences are therefore useful guides for future operations.

Feasibility Guide - Hoover et al. (1959) developed criteria for the selection of translocation sites for grasslands in Colorado. Eight of these criteria bear repeating with only slight modifications more than 40 years later:

> *1. Unless sufficient continuous rangeland is available to allow a translocated herd to be maintained or expanded, the site should be rejected. As a rule, each animal requires at least 1 square mile (2.6 km^2) of native grassland, and the number of animals should not be less than 100.*
>
> *2. Pronghorn feed primarily on forbs and shrubs, therefore, a good variety and production of these should be present. Rangelands in poor ecological condition or dense, high shrublands are not desirable.*
>
> *3. Concurrent use of rangelands by domestic livestock (cattle, horses, and sheep) should be evaluated. This involves competition for forage and water as well as compatibility, the presence of fences, predator control practices, and whether pronghorn or livestock might transmit diseases from one animal to the other.*
>
> *4. Depredation on agricultural crops is a potential conflict that needs evaluation. Isolated fields surrounded by rangelands usually are subject to more depredation than are numerous fields.*

5. A map illustrating the land ownership pattern should be prepared, especially if private lands are involved. Public lands are preferred, followed by large blocks of private lands with one owner. The least desirable sites are private lands in small units with many owners.

6. Reactions of people to an introduction should be considered, particularly those of local conservation organizations, personnel charged with administering public lands, livestock permittees, and private land-owners. It should also be ascertained whether the landowners would be agreeable to hunting on their property.

7. If all the above factors are satisfactory, written permission should be secured from all public land agencies and private land-owners in the area prior to the release.

8. It is also desirable to provide for alternate release sites to allow for last minute hitches, inclement weather, road conditions, etc.

Table 1. Form used for the selection of pronghorn transplant sites.

1. LOCATION:

   County _____ Nearest town _____

   Nearest ranch _____ Accessibility by road _____

   Township _____ Range _____

2. SIZE (Number of square miles of estimated habitat):_____

3. TOPOGRAPHY: _____ Physical Barriers: _____

   Constructed Barriers:

Fences (Location)	(Construction Specifications)
_____	_____
_____	_____

   Major Highways, freeways _____

   Other: _____

4. CLIMATE: _____ Elevation _____

   Mean depth of snow _____ Annual Precipitation _____

5. WATER:

	Springs	Reservoirs	Lakes	Streams	Wells	Catchments
Number	_____	_____			_____	_____
Acres			_____			
Miles				_____		
Production:						
Surface Ac.		_____				
Gal/Min	_____			_____		
Gal/Storage						_____

   Mean distribution of water sources _____

   Year-round water? _____

6. VEGETATION:

Major Types	No. Acres	Mean Ht.	Estimated Percent Grass	Forbs	Shrubs
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

7. LAND OWNERSHIP (number of acres):

   Private _____

   Public _____

   Other _____

8. LAND USE:

   Class of livestock _____

   Stocking rate _____

Table 1. Continued.

Grazing system _____

Cultivated crops _____

Other _____

9. PREDATION:

Natural: Coyotes _____ Eagles _____ Bobcat _____

Human _____

10. TRANSPLANT CONSIDERATIONS:

Is site historical pronghorn range? _____

Attitude of ranchers _____

Attitude of conservation organizations _____

Attitude of local sportsmen's clubs _____

_____

Attitude of public land-management agencies _____

Is land manager(s) agreeable to management objectives of state or provincial wildlife agency? _____

Suggested number of pronghorn for transplant _____

Route of trucks carrying pronghorn and release point _____

_____

_____

Has a "habitat management plan" been developed? _____

_____

_____

Are cooperative agreements completed?

Private landowners _____

Public land agencies _____

Has a follow-up monitoring study been planned to document success of project or reasons for failure? _____

_____

_____

Other _____

_____

_____

[a]Modified from Hoover et al. (1959) for shrub steppes by Yoakum (1980).

Table 1. Form used for selecting pronghorn transplant sites.

As a guide for determining an appropriate release site, Hoover et al. (1959) developed a form recommended for completion prior to release on grasslands. Yoakum (1980) adapted the form for shrubsteppes, and this form warrants attention from managers planning translocations (Table 1). A similar form is also in use by the Game Management office of the Arizona Game and Fish Department to evaluate semidesert and other grassland sites.

Habitat Suitability Criteria – Determining suitable habitat for pronghorn is related to the right amount and juxtaposition of all habitat characteristics meeting the species' biological requirements. Knowledge of these habitat requirements is the ecological foundation for managers making translocation decisions (Yoakum 2004).

Suitable habitat for pronghorn can be determined through a system of rating habitat characteristics. Too little or too much of any biotic or abiotic factor may limit pronghorn production and survival. Knowledge of these relationships becomes the ecological foundation for making proper management decisions.

Quantitative rating systems have been developed to assess: winter rangelands (Allen and Armbruster 1982), translocation sites (McCarthy and Yoakum 1984, Arizona Game and Fish Department 1993), suitable year-round habitat (U.S. Bureau of Land Management 1980, U.S. Soil Conservation Service 1989), effects of wildfires on vegetation (U.S. Bureau of Land Management 1980), and the compatibility of domestic sheep to pronghorn (Howard et al. 1990). These rating systems have been used to evaluate pronghorn habitat in documented reports, thereby advancing pronghorn management from earlier "professional judgment" efforts to using written scientific criteria.

Habitat suitability was used as the main criterion for evaluating five potential shrub-steppe translocation sites in Mono County, California (McCarthy and Yoakum 1984). Similar strategies for evaluating sites can be used in assessing other potential release sites, to establish priorities, and to provide insight into the feasibility of a transplant. Procedures for choosing the best five sites included an evaluation of 9 criteria:

1. *Habitat suitability was evaluated for water, vegetation quality (percent forbs, shrubs, and grasses), vegetation height, and forage quantity using criteria established by Yoakum (1980).*

2. Mean winter snow depths were interpolated using data from weather stations. Areas were considered suitable for winter use if mean snow depths were less than 10 inches (25 cm).

3. Natural physical barriers were evaluated to determine potential for restriction of pronghorn movements. Major physical barriers included large ravines, mountain ranges, and dense shrub or timbered areas.

4. The potential size of each release site was determined by using a polar planimeter and 7.5-min U.S. Geological Survey quad maps. Optimum area size was considered >100 square miles (259 km^2).

5. Livestock fences were evaluated in relation to pronghorn passability. A barbed-wire fence was considered passable if the bottom wire was at least 16 inches (41 cm) from the ground.

6. Potential for predation on pronghorn was subjectively rated in terms of high, moderate, or low. Predator abundance information was obtained from various government agency personnel, ranchers, and individuals familiar with the sites.

7. Potential for crop depredations was estimated on the basis of location of agricultural crops in relation to each site. Distances were determined to the nearest cultivated field and a depredation potential rating of high, moderate, or low assigned to each area.

8. Seasonal suitability was evaluated on the basis of food availability and whether or not an area could support pronghorn on a year-round basis.

9. Potential for forage competition with livestock was estimated on the basis of class of livestock, animal unit months, and grazing systems. Each site was rated as having high, moderate, or low potential for livestock/pronghorn conflicts.

Following the evaluation of each site, limiting factors were addressed on the basis of the above criteria. The sites were compared with each other and prioritized in terms of the site(s) with the greatest potential for a successful pronghorn transplant. This system provided two components to help select the best potential release site: (1) it was based on ecological data collected in the field, and a numerical rating denoted the site with the highest potential; and (2) potential limiting factors were identified so that remedial measures could be taken prior to any releases, thus providing a better chance for a successful translocation.

In conclusion, the following guidelines are recommended for pronghorn translocations:

1. Translocation sites should be evaluated for habitat suitability prior to any animals being captured. Each state or province should establish a rating system that considers regional conditions and topography. Areas that do not meet such specifications should not be considered feasible until conditions meet all of the criteria required.

2. Multiple translocation sites should be prioritized to establish which areas have the highest potential for successful translocations. Ideally this should be done on a statewide, province-wide, or regional basis to assure that translocations are made only in the highest quality sites.

3. Habitat suitability criteria should be continually fine-tuned for site-specific release areas. Ratings for topography, vegetation and water availability should be modified to reflect ecological conditions within a state, province, or region.

4. Translocation projects should include monitoring the success of animals after release. This is important in developing and modifying translocation guidelines and ensuring accountability in translocation endeavors.

Care and Captive Management: Captive pronghorn have had an important management role since the early 20th Century (Brunner 1910, Floyd 1924, Nelson 1925, Nichol 1942, and Einarsen 1948), and continue to do so depending on the purpose involved. The main functions of captive pronghorn include public display, research, rehabilitation, and to assist in recovery efforts (Schwartz et al. 1976, Brinkley 1987, Wild and Miller 1991, Raisbeck et al. 1996, Blunt and Myles 1998, Lindstedt et al. 1991, Cancino et al. 2001). There are therefore captive pronghorn in zoos, on private ranches, at universities, and in public and private parks.

Depending on the objectives, a captive management program may employ a wide range of practices and facilities. For example, although the pronghorn on the National Bison Range are considered wild, all of the animals are fenced in, and essentially captives. The same holds true for the pronghorn on Antelope Island near Salt Lake City, Utah, and an enclosure on the El Vizcaíno Biosphere Reserve in Baja California Sur, even though the purpose of the former is primarily aesthetic, and the latter is part of a recovery effort for the endangered peninsular pronghorn (Tullous and Fairbanks 2002, Cancino et al. 2001). These and other facilities can be divided into three basic groups: 1) public display areas where animals are fed and receive medical care and other amenities on a regular basis; 2) research enclosures composed of corrals, pastures, and other facilities where the animals are more or less under constant observation (e.g., Sybille Wildlife Research Unit in Wyoming or the Foothills Wildlife Research Facility at Fort Collins, Colorado); and 3) large fenced areas within habitat that contain such basic facilities as water and food (Byers 1997, Blunt and Myles 1998, and Cancino et al. 2001).Depending on the objective the facilities may be used to hand rear and wean captured fawns, provide “soft care” for animals under observation, or intensively train research subjects.

Figure 24. At times management objectives may provide artificial or emergency feeding. For example, alfalfa hay was provided and readily used by pronghorn on the Carrizo Plain during a severe drought. Another case is pictured here where pronghorn were raised for future releases to historic rangelands on the Vizcaino Desert, Mexico. Photo by Ramon Castellanos.

Hand rearing captured fawns is the simplest way to start a captive herd. Once the fawns are removed from the wild, there are several protocols for bottle raising them (Schwartz et al. 1976, Brinkley 1987, Wild et al. 1994, and Martin and Parker 1997). The main differences are in the composition, mixing procedures, and volume of the formula. Although methods of alleviating gastrointestinal distress differ, all have the same goal--successfully raising fawns to the weaning stage. The hand raising process can be divided into five periods—adaptation, initiation, development, concluding, and weaning. The first or adaptation period is to accustom the fawns to feed from the bottle. Evaporated milk is used as a base, with or without boiled water. Eight days with an offer of a 5 to 8-ounce (.15 to .24 l) bottle should be sufficient. The initiation phase using a 10-ounce (.30 l) bottle for two weeks then begins.

The development period lasts about 50 days. During this phase, larger amounts of food are offered. According to the protocol selected, *i.e.*, the amount of milk mixed with the boiled water, milk consumption gradually increases until the consumption of vegetation begins. Depending upon the situation, the vegetation eaten can be native plants, alfalfa hay (*Medicago* sp.), or a mixture of the two. Salt blocks should also be accessible during this stage.

The length of the concluding period can be adjusted depending on the number of fawns involved and the weaning schedule desired. This adjustment should also consider the age when individual animals were captured, with the younger animals requiring more time than those caught later in the season. In pronghorn, permanent teeth replace the “baby teeth” at about 16 months of age (Jensen 1998).

Places like the National Bison Range require little overt care other than observation and other "soft care" techniques, and the periodic removal or restocking of individuals. Byers (1997) presents a detailed description of the monitoring and other procedures used at this and similar locations. Captive animals nonetheless always present the possibility for accidents, e.g., rattlesnake bites (Miller et al. 1989) or surgical emergencies. "Lumpy jaw" lesions associated with infected teeth roots are not uncommon in captive animals, and bacteria isolated from these jaw and mandibular abscesses include *Arcanobacter pyogenes* and *Fusbacterium necrophorum*. In addition to lancing and draining abscesses, treatment with antibiotics is often required to manage lesions (M. Wild, *pers. com*). As a consequence, it is usually advisable to have a veterinary staff on the premises, and under optimal conditions preventive medicine protocols would include annual treatment with vaccines as is done for domestic sheep. Euthanasia needs to also be considered in some cases.

Schwartz et al. (1976) described animals subjected to intensive training for ecological studies, Lindstedt et al. (1991) discussed the laboratory use of pronghorn in energetic studies, and Raisbeck et al. (1996) evaluated the susceptibility to selenosis. As stated the reader is urged to consult the original reports for greater detail.